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Stored-Grain Pests

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MOST of the damage done by insects to grain in storage and shipments is brought about by four species. These are the granary weevil, the rice or black weevil, the lesser grain borer or Australian wheat weevil, and the Angoumois grain moth. Other species or groups of species described in this bulletin can cause great damage to grain if storage conditions are unusually favorable for their increase. Yet if grain in the unbroken kernel remains unaffected by the four insects mentioned, it is not likely that any other insect will damage it appreciably in commercial storage or shipments, except for the khapra beetle which at present has a limited distribution.

The secondary pests discussed herein are for the most part surface feeders in both adult and larval stages. Some may eat their way into kernels of grain and lie hidden there; most of them are found feeding upon grain dust or broken surfaces of kernels exposed either by mechanical injuries to the grain in handling or by the feeding of the four primary grain pests with which they are usually associated. They can therefore be largely removed by grain-cleaning operations.

With the exception of the lesser grain borer, the larvae, or grubs, of the primary pests mentioned are not ordinarily capable of a free existence outside the kernel. They live entirely within the kernel, where they feed unseen and usually unsuspected. They cannot be removed by ordinary cleaning machinery and must be controlled by other means. Methods of preventing infestation of grain are discussed briefly.

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STORED-GRAIN PESTS

Prepared by the Stored-Product Insects Research Branch, Market Quality Research Division, Agricultural Research Service

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POPULAR CLASSIFICATION OF GRAIN PESTS

SINCE the establishment of the Federal standards for grain under the provisions of the Grain Standards Act, Federal grain supervisors and federally licensed grain inspectors have been required to identify the various species of "live weevils and other insects injurious to stored grain" which may be present in the grain. Uniform names for grain insects should be used. Such uniform terminology will indicate definitely to all interested persons, including shipper, purchaser, and elevator operator, the exact nature of the insect found. Of the four major pests, the granary weevil, the rice or black weevil, and the lesser grain borer may well be called grain weevils. The fourth of the major pests, the Angoumois grain moth, so destructive to wheat and corn, may be called a grain moth. Other insects likely to be

found in any lot of grain may be called simply beetles, moths, and mealworms, for their presence usually does not indicate a condition likely to affect the trade, provided that after the grain has reached the elevator it is screened and fanned to remove these insects.

In this bulletin are discussed grain weevils, grain borers, grain moths, flour moths, grain and flour beetles, mealworms, dermestid beetles, spider beetles, miscellaneous beetles, booklice or psocids, silverfish, cockroaches, flour or grain mites, and parasites of grain pests.

GRAIN WEEVILS

Of the four true weevils that attack grain in the United States, only two are of primary importance—the granary weevil and the rice or black weevil. The broad-nosed grain weevil and the coffee bean weevil are of minor importance, except locally. These four weevils have elongated beaks or snouts, as the illustrations show, though the beak of the coffee bean weevil is greatly reduced.

Granary Weevil

The granary weevil (*Sitophilus granarius* (L.)) (fig. 1) is a small, moderately polished, chestnut-brown or blackish beetle with head prolonged into a long slender snout, at the end of which are a pair of stout mandibles or jaws. It is not more than three-sixteenths of an inch long and often is smaller. It has no wings under its wing covers, and the thorax is well marked with longitudinal punctures, two characteristics that distinguish it from the closely related rice weevil, with which it is often found associated. The well-grown footless, whitish grub or larva and the pupa are shown in figure 1, *a* and *b*. The granary weevil is one of the oldest known insect pests, is a universal feeder upon grains, and is cosmo-

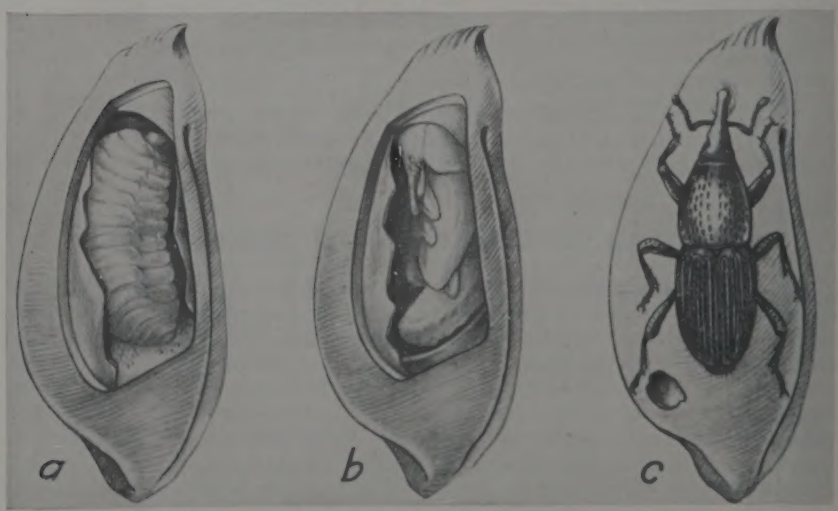

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Figure 1.—Life stages of the granary weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult. Note hole in kernel made by the adult in order to leave the seed and hole that it is eating into the kernel for the purpose of laying eggs. The adult is never more than three-sixteenths of an inch long.

politan, having been carried by commerce to all parts of the world. It prefers a temperate climate and is more frequently found in the Northern States than in the South.

Both adults and larvae feed voraciously on a great variety of grains. The adult weevils live, on an average, from 7 to 8 months, the females laying from 50 to 250 eggs each during this period. Before laying her eggs, the female bores a small hole in the grain berry with her mandibles. When this has been made she turns about and lays in it an egg, which she then covers with a gelatinous fluid that seals the hole. The small, white, fleshy, and legless grubs that hatch from the eggs burrow about inside the kernels. When fully grown, these transform to the pupal stage and then into the adult-weevil form.

In warm weather the granary weevil requires about 4 weeks to complete its development from the egg to the adult weevil. The developmental period is greatly prolonged by cold weather.

Rice or Black Weevil

The rice or black weevil (*Sitophilus oryzae* (L.)) is a small snout beetle which varies considerably in size but rarely measures more than one-eighth of an inch in length (fig. 2). It varies in color from reddish brown to nearly black and is usually marked on the back with four light reddish or yellowish spots. It closely resembles the granary weevil in form, but it has well-developed wings beneath its wing covers, differs in color and markings, and has the thorax densely pitted with round, instead of longitudinal, punctures. Figure 2 gives a good impression of the appearance of the rice weevil and its earlier stages.

This weevil has been known from early times. It is found in all parts of the world where grain is used and is one of the very worst pests in stored grain. It is particularly abundant in warm countries, where it breeds continuously and rapidly destroys all unprotected grain.

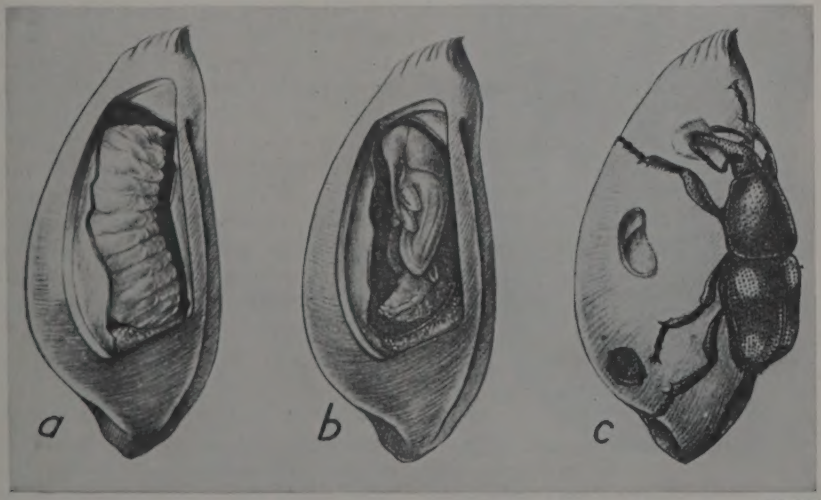

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Figure 2.—Life stages of the rice or black weevil in wheat: *a*, Well-grown larva; *b*, pupa; *c*, adult feeding upon kernel. Note in *c* the hole in lower portion of kernel made by the adult on leaving the seed and at two points higher up shallow holes made by the adult in feeding upon the seed after emergence. The adult rarely measures more than one-eighth of an inch in length.

Throughout the South it causes tremendous losses to corn (fig. 3), reducing the kernels to dry powder and hulls, and is the commonest of the serious pests of commercial grain shipments.

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Figure 3.—An ear of corn badly damaged by rice or black weevils. This ear has been hit against a table to jar loose the powdery substance, sometimes called the farinaceous material, and so reveals the great damage done by the weevils.

The adult weevil lives, on an average, 4 or 5 months, each female laying between 300 and 400 eggs during this period. The early stages are almost identical in habit and appearance with those of the granary weevil and need not be further described. The rice weevil is a strong flier. The adults fly from granaries to the fields of grain and there start the infestation that often proves so disastrous after the grain has been harvested. During summer weather the egg, larval, and pupal stages may be passed in as few as 26 days. This period, of course, is greatly prolonged during cool or cold weather.

Broad-Nosed Grain Weevil

The broad-nosed grain weevil (*Caulophilus oryzae* (Gyllenhal)) is a small dark-brown snout beetle slightly less than one-eighth of an inch long. In form and color it resembles the granary weevil somewhat but differs from it and from other grain-infesting weevils by having a short, broad snout (fig. 4).

This weevil is occasionally found in Georgia and South Carolina and is widespread in Florida, where it is a serious pest of stored grains, but it is not found in grains grown in the North. It is unable to breed in dry, hard, uninjured grain, but attacks soft or damaged grain, or grain that has been attacked by other grain insects. It is a strong flier, and, like the rice weevil, flies to the cornfields and infests the grain before it becomes fully hardened.

The adult weevils normally live for about 5 months, and during this

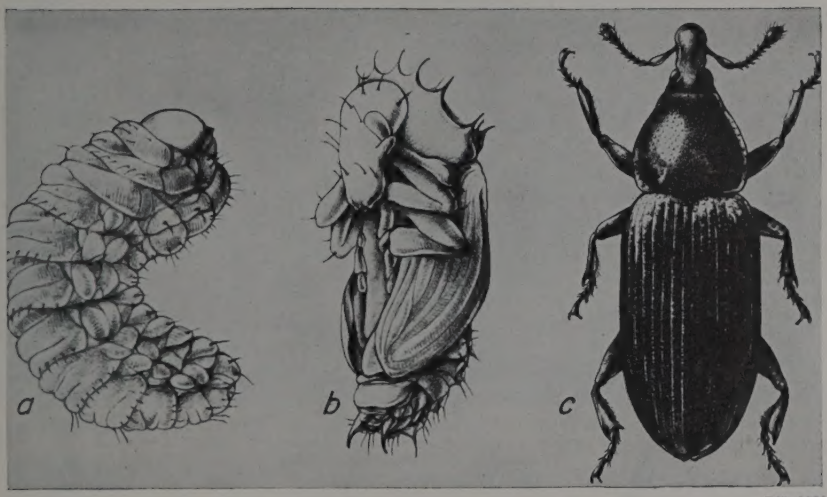

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Figure 4.—The broad-nosed grain weevil: *a*, Full-grown larva; *b*, pupa; *c*, adult weevil. The adult weevil is slightly less than one-eighth of an inch long.

time the females lay between 200 and 300 small white eggs, usually in broken portions of the grain. The eggs hatch in a few days, and the small, white, legless grubs feed on the softer portions of the grain until fully grown. They then change to a white pupal form, which in a few days transforms to the adult beetle and cuts its way out of the grain. In summer the period from egg to adult is about 1 month.

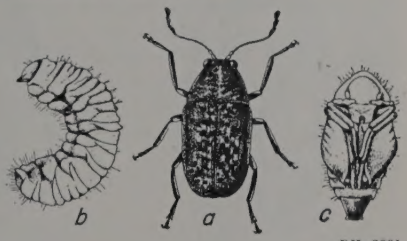

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Figure 5.—The coffee bean weevil: *a*, Adult; *b*, well-grown larva; *c*, pupa. The adult is about three-sixteenths of an inch long.

Coffee Bean Weevil

The coffee bean weevil (*Araecerus fasciculatus* (DeG.)) is a very active, robust dark-brown beetle from two-sixteenths to three-sixteenths of an inch long, clothed with a mottled light- and dark-brown pubescence. It may be easily recognized from figure 5.

This weevil is found in many countries and is extremely abundant in the Southern States, where it breeds in dried fruit, coffee berries, cornstalks, corn, and the seed and seed pods of an almost endless variety of plants. It is a strong flier and is frequently to be seen in the cornfields of the South on the exposed and damaged ears. It lays its eggs in the soft kernels of corn, and breeding continues after the corn has been harvested and placed in storage. It does not cause much damage to corn in storage, as the corn becomes too hard to be attractive. It may, however, be very abundant locally in corn in Florida during the first 3 months of storage and has been reported as completely destroying a sack of kafir seeds in Honolulu. Over the country at large, the coffee bean weevil is a very minor grain pest.

GRAIN BORERS

Three species of grain borers are now established in the United States. The lesser grain borer is now widespread in the grain centers of this country and is a serious pest of stored grain. The larger grain borer and the bamboo borer are confined to the Southern States and are not of commercial importance.

Lesser Grain Borer

The lesser grain borer (*Rhyzopertha dominica* (F.)) is one of the smallest beetles injurious to grain in this country. It is known to many grain dealers more popularly as the Australian wheat weevil because of the large supplies of wheat infested by it that reached this country from Australia during World War I. It is widespread in the Gulf States, and grain samples infested with this beetle are to be found in all large grain centers. It is readily distinguished from other grain pests by its slender cylindrical form and small size. It is polished dark brown or black, with a somewhat roughened surface, about one-eighth of an inch long and one thirty-second of an inch wide. The larval, pupal, and adult stages are illustrated in figure 6. It belongs to a family (Bostrichidae) of beetles that have the head turned down under the thorax and are armed with powerful jaws with which they can cut directly into wood. Originally native to the Tropics, the lesser grain borer has spread through commerce to all parts of the world.

Both beetles and larvae cause serious damage in warm climates, attacking a great variety of grains. The destruction of which they are capable is shown by the wheat kernels of figure 7, which are literally riddled by the boring adults and their young. The damaged kernels are always surrounded by powder from the chewed-up grain. The females lay from 300 to 500 eggs each, dropping them singly or in clusters in the loose grain. The eggs hatch in a few days, and the small whitish grubs crawl actively about the grain, feeding on the flour produced by the boring of the beetles, or boring directly into

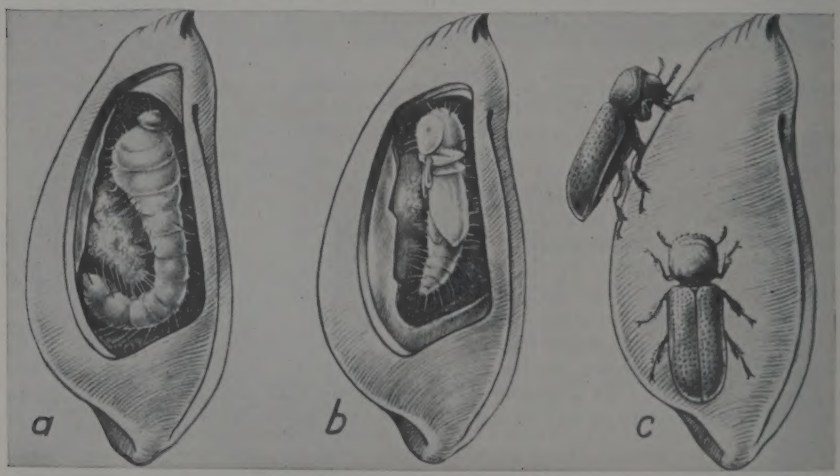

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Figure 6.—The lesser grain borer in and on wheat kernels: *a*, The well-grown larva; *b*, the pupa; *c*, two adult weevils. Adult borer is about one-eighth of an inch long.

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Figure 7.—Kernels of wheat thoroughly riddled and devoured by the boring and feeding of the lesser grain borer and its larva.

grains that have been slightly damaged. They complete their growth within the grain, transform to white pupae, and in time change to adult beetles which cut their way out of the grain. The period from egg to adult in summer is said to be about a month.

Larger Grain Borer

The larger grain borer (*Prostephanus truncatus* (Horn)), is a small, dark-brown, elongate-cylindrical beetle about one-sixth of an inch long. As may be seen in figure 8, it is very similar in ap-

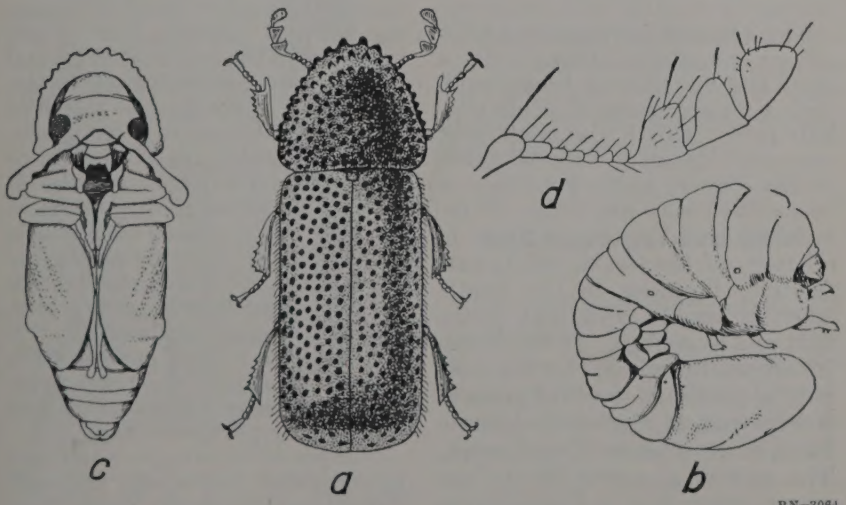

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Figure 8.—Adult and immature stages of the larger grain borer: *a*, Adult insect; *b*, larva; *c*, pupa; *d*, antenna of adult. The adult beetle is about one-sixth of an inch long; the antenna in *d* is highly magnified.

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pearance to the lesser grain borer, but it may be distinguished by its larger size and comparatively smooth, polished surface.

This beetle is a tropical insect not as yet widely distributed in this country. It is occasionally found infesting corn (fig. 9) in the South.

BN–3065

Figure 9.—Kernel of corn showing the work of the adult of the larger grain borer.

It has been reported from Texas, California, and the District of Columbia. Like the lesser grain borer, it belongs to a family of beetles (Bostrichidae) that are mainly destructive to timber. Its habits are similar to those of that beetle. It also has probably acquired its grain-feeding habits rather recently.

One other member of the family Bostrichidae, *Dinoderus minutus* (F.), the bamboo borer, occasionally infests stored grain in the United States. It has been recorded from Louisiana and Florida. In general appearance it resembles the larger grain borer.

GRAIN MOTHS

The term "grain moth" includes only those moths capable of destroying sound, unbroken grain kernels. They are not so abundant as the flour moths, which are principally pests in broken, damaged kernels or milled products.

Angoumois Grain Moth

The Angoumois grain moth (*Sitotroga cerealella* (Oliv.)) is a small buff or yellowish-brown moth with a wing expanse of about one-half inch. This is the moth most commonly found in infested grain in this country and is not likely to be confused with any other. It attacks all cereal grains, is found in all parts of the world, and is particularly injurious in the South, where it attacks grain both in the field and in storage. In the North it survives the winter, for the most part as larvae in kernels of grain in storage and in scattered wheat in litter, straw piles, and baled straw. The emerging moths fly to the wheatfields in May and deposit eggs upon the developing grain.

Under normal conditions each female lays an average of about 40 eggs, although under favorable conditions individual moths have been known to lay as many as 389 eggs. The eggs, which are white when first laid, soon change to a reddish color. They are laid on wheat heads, on the exposed tips of ears of corn in the field, or on grain in storage. Upon hatching, the young larva crawls to a kernel of grain and often spins a small entrance cocoon to assist it in boring into the hard kernel. After entering the grain, it feeds on either the endosperm or the germ until fully grown, when it eats out a channel to the outside of the seed and prepares an exit hole through the seed coat by cutting the shell for one-half or three-fourths of the circumference of a circle, making a weakly fastened flap. A silken cocoon is spun, and the larva changes to a reddish-brown pupa. Later, as a moth, it pushes its way through the partly cut flap.

The period from egg to adult may be completed in 5 weeks, although development is usually slower than this.

Owing to the widespread use of the combine harvester, damage to wheat by this moth has been reduced to a minimum. However, in the southern portion of the commercial corn growing area, it periodically causes heavy losses to stored corn. Figure 10 shows an ear of corn with the external evidence of a heavy attack by the Angoumois grain moth. Figure 11 shows the successive stages in the development of this insect in a kernel of wheat from the time the egg is laid until the adult appears.

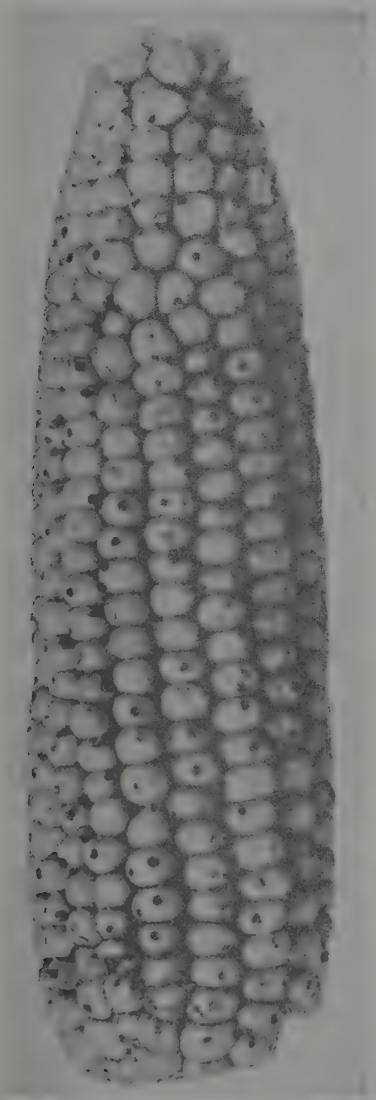

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Figure 10.—Ear of popcorn showing heavy infestation by the Angoumois grain moth. Note that certain of the kernels have three emergence holes, and that many have served as food for two larvae.

European Grain Moth

The European grain moth (*Nemapogon granella* (L.)) (fig. 12) is a small moth about the size of the Angoumois grain moth, creamy white and heavily mottled with brown. The mottled appearance distinguishes it from the Angoumois grain moth. It infests all kinds of grain, both in the field and in storage. The larva feeds on the grain and webs the kernels together.

This moth is distributed throughout the Northern States but is not very abundant and cannot be compared with the Angoumois grain moth for destructiveness.

Pink Scavenger Caterpillar

The pink scavenger caterpillar (*Sathrobrota rileyi* (Wals.)) (fig. 13) is the larva, or caterpillar, of a small moth. It is about five-sixteenths of an inch long when full-grown; pink, with head and thoracic shield pale brown. The moth which develops from this worm or larva is smaller than the Angoumois

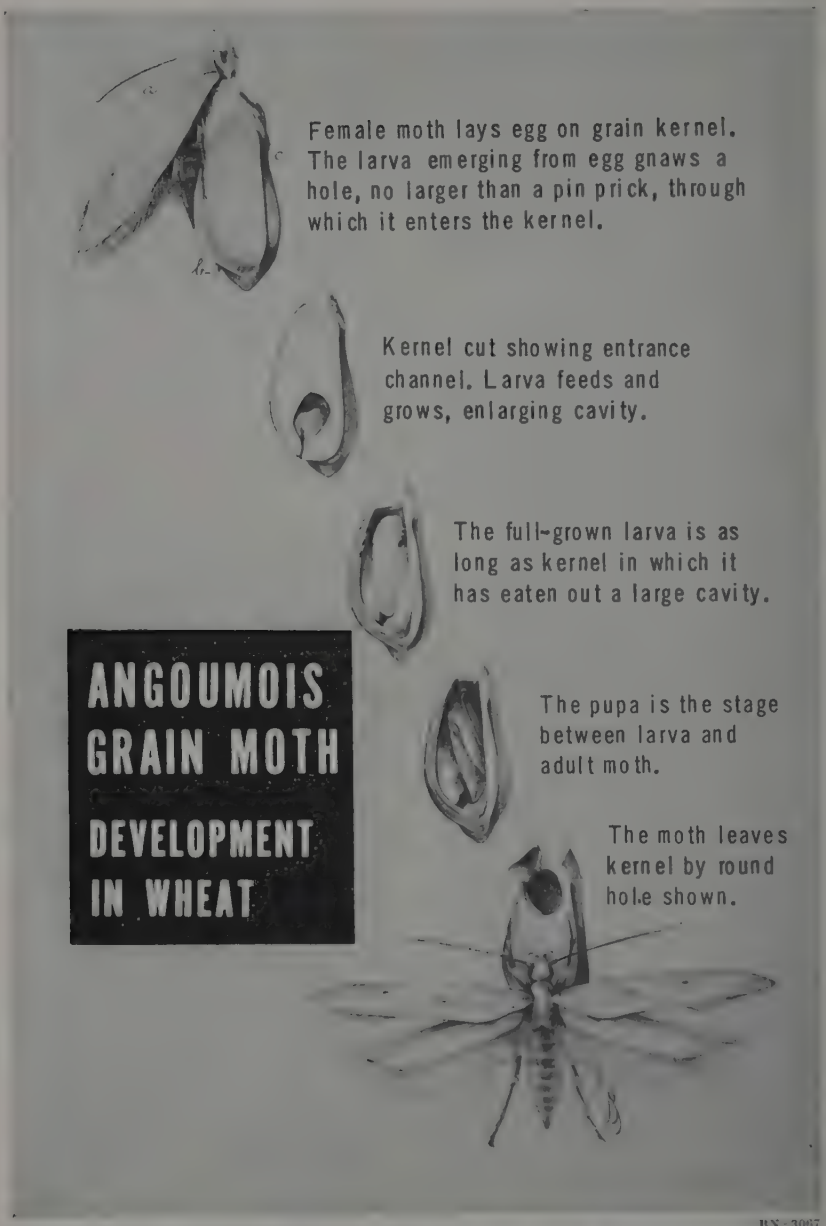
Female moth lays egg on grain kernel. The larva emerging from egg gnaws a hole, no larger than a pin prick, through which it enters the kernel.
Kernel cut showing entrance channel. Larva feeds and grows, enlarging cavity.
The full-grown larva is as long as kernel in which it has eaten out a large cavity.
ANGOUMOIS GRAIN MOTH DEVELOPMENT IN WHEAT
The pupa is the stage between larva and adult moth.
The moth leaves kernel by round hole shown.
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Figure 11.—Life cycle of the Angoumois grain moth on wheat.

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Figure 12.—Adult of the European grain moth (*Nemapogon granella* (L.)). The moth has a wing expanse of about one-half inch.

grain moth, with a wing expanse of slightly less than half an inch. The forewings are banded and mottled with yellow, reddish brown, and black. The pale grayish hindwings are very slender and are edged with long fringes (fig. 14).

This insect is common in the South, where it causes considerable injury to corn, both in the field and in storage. Infestation begins in the field and is continued after the corn is placed in storage. The very characteristic injury is shown in figure 15. The large amount of frass that is loosely webbed together and fills the interstices between the kernels or is crowded into the cavities of kernels that have been eaten out is a reliable indication of the presence of this pest. The pearly white eggs are laid singly, or occasionally in twos or threes. The pinkish larvae feed on the seed, husk, and cob with equal relish. Though capable of serious injury to corn, in particular as it comes to maturity in the field and while in the cribs on southern farms, the pink scavenger caterpillar is seldom a serious pest of commercial shipments.

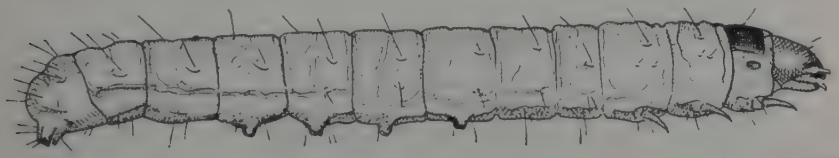

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Figure 13.—The pink scavenger caterpillar: Full-grown larva, side view, greatly enlarged. When full-grown, the larva is about five-sixteenths of an inch long.

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Figure 14.—The pink scavenger caterpillar: Moth, much enlarged; head and leg more enlarged. The moth has a wing spread of a little less than half an inch.

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Figure 15.—Ear of corn cut to show characteristic feeding and destruction by pink scavenger caterpillar larvae. Note that the larvae eat from one kernel to another, often severing the kernels from the cob. The larvae sometimes eat into the cob, and there transform to the pupal stage. The pupae are about one-third as long as the kernels shown.

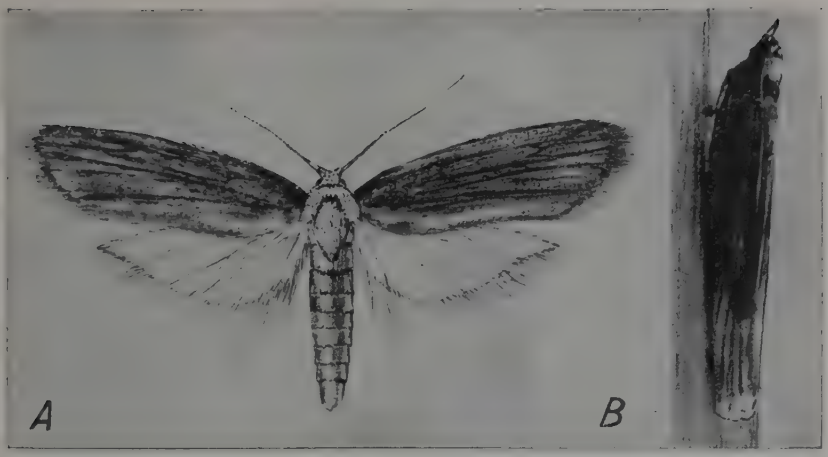

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Figure 16.—The rice moth: *a*, Mature moth, dorsal view, with wings spread; *b*, side view of same moth with wings folded about body. The moth has a wing spread of about half an inch.

Rice Moth

The rice moth (*Corcyra cephalonica* (Staint.)) has a wing expanse of about half an inch and is pale grayish brown or tawny. Its characteristic appearance is shown in figure 16. The larva (fig. 17) resembles somewhat that of the Indian-meal moth, being, when full grown, about half an inch long and varying from white to a dirty, slightly bluish gray with occasional tints of green. Damage by the pest, as in the case of all moth pests, is done by the larvae, which are rather general feeders. They attack such materials as rice, cocoa, chocolate, dried fruit, biscuits, and seeds. The larvae produce a dense webbing as they become full-grown. When feeding upon grains, they spin dense silken tubes, webbing the grain kernels into the walls of the tubes. The moths live from 1 to 2 weeks, the females laying between 100 and 200 eggs each. In summer, development from egg to adult covers a period of about 6 weeks. The rice moth has not as yet become very widely disseminated in this country.

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Figure 17.—Full-grown larva of the rice moth. The full-grown larva is about one-half inch long.

FLOUR MOTHS

Among the flour moths are some of the commonest and most serious pests of grain products. They are designated as flour moths, not because they feed entirely upon flour or milled products, but because they seldom attack sound kernels. They prefer broken grains, grains injured by major grain pests, and more especially cereal milled products such as flour, breakfast foods, and meals. All three of the flour moths are commonly found in grain warehouses, but the Indian-meal moth and the meal moth are probably the most frequently reported. These two moths may, under exceptionally favorable conditions, become established in whole grain and other seeds and cause injury, especially by eating out the germ.

Figure 18.—The Indian-meal moth: *a*, Moth with wings spread; *b*, moth with wings folded as ordinarily seen when the moth is resting on some surface in the warehouse. The moth has a wing expanse of nearly three-fourths of an inch.

Indian-Meal Moth

The Indian-meal moth (*Plodia interpunctella* (Hbn.)) is a rather handsome moth with a wing expanse of nearly three-fourths of an inch (fig. 18). It is easily distinguished from other grain pests by the peculiar marking of its forewings. These are reddish-brown with a coppery luster on the outer two-thirds, but whitish gray on the inner or body end. The female moths lay from 100 to 300 eggs, singly or in groups, on food material. The eggs hatch within a few days into small whitish larvae or caterpillars. These larvae feed upon grains, grain products, dried fruits, nuts, and a rather wide variety of foodstuffs. When full-grown, the larvae are about half an inch long, dirty white, varying sometimes to greenish and pinkish hues. A full-grown larva is shown in figure 19, clinging to a kernel of wheat. This larva spins a silken cocoon and transforms to a light-brown pupa, from which the parent moth later emerges. The Indian-meal moth may pass through its egg, larval, and pupal stages in from 6 to 8 weeks during warm weather.

The larva of the Indian-meal moth spins a web as it becomes full-grown and leaves behind a silken thread wherever it crawls. When sacks of cracked corn, meal, or corn in the ear that has been previously injured by other pests become heavily infested, this webbing often is sufficiently abundant to attract attention. The loosely clinging web shown on the ear of corn in figure 20 is characteristic of this pest.

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Figure 19.—Well-grown larva of the Indian-meal moth, crawling on kernel of wheat. Much enlarged.

Mediterranean Flour Moth

The Mediterranean flour moth (*Anagasta kuehniella* (Zell.)), has a wingspread of slightly less than 1 inch. Its hind wings are a dirty white, but its forewings, which alone show when the moth is not flying, are a pale leaden gray with transverse wavy black markings (fig. 21).

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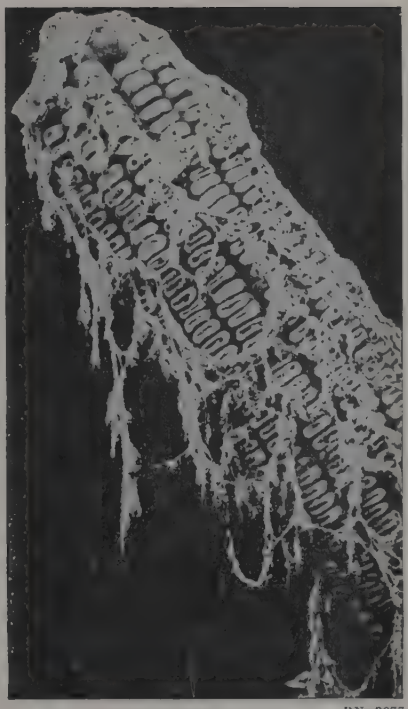

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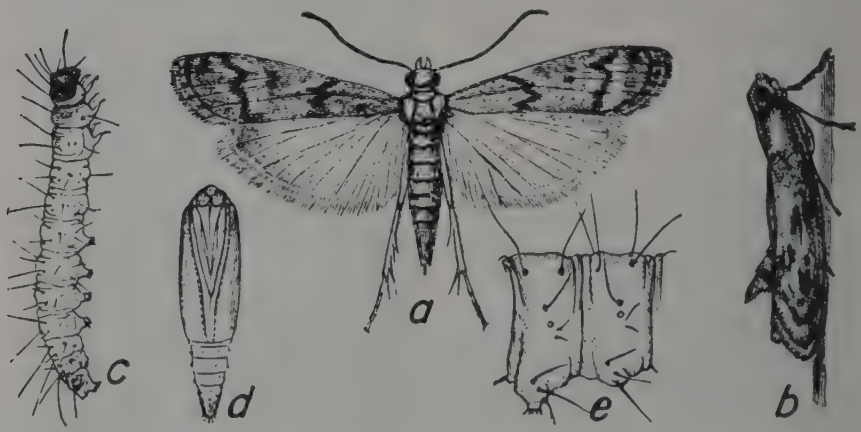
Figure 20.—Ear of corn showing the characteristic loose webbing left by larvae of the Indian-meal moth. This moth rarely attacks sound grain, but, as in this picture, frequently attacks grains already injured by other grain pests. Such webbing as is here shown develops only when corn or other grains are left unmoved for some time.

The Mediterranean flour moth is a native of Europe. Its first discovery in the United States was in California in 1892. Since that time it has become widespread over the country and for many years was considered the most troublesome pest of flour mills. The larvae spin silken threads wherever they go, webbing and matting together particles of food in which they are feeding. In flour mills, the machinery sometimes becomes so clogged with the matted flour that milling operations are halted. In mills that have an annual fumigation this insect is no longer a major

problem. Although preferring flour and meal, the Mediterranean flour moth attacks grain, bran, cereal products, and many other foodstuffs.

or cereal products. *C. cautella* is more troublesome than the other two, is a serious pest of rough rice and grain sorghum in the South, and is common in seed stores.



BN-3078

Figure 21.—The Mediterranean flour moth: *a*, Moth; *b*, same from side, resting; *c*, larva; *d*, pupa (enlarged); *e*, abdominal joint of larva (more enlarged). The adult moth has a wing expanse of a trifle less than 1 inch.

The female moth lays small white eggs in accumulations of flour, meal, or waste grain. From the eggs the small larvae hatch in a few days. When full-grown, these are about half an inch long and are whitish or pinkish, with a few small black spots on the body. The full-grown larva spins a silken cocoon in which the insect transforms to a reddish-brown pupa. Later, the parent moth emerges from the pupa. During warm weather the Mediterranean flour moth requires 8 or 9 weeks to pass through its egg, larval, and pupal stages.

Three species—*Cadra cautella* (Wlkr.), *Ephestia elutella* (Hbn.), and *Cadra figulilella* (Greg.)—are occasionally found infesting grain

Meal Moth

The meal moth (*Pyralis farinalis* (L.)), is brownish and somewhat larger than the Indian-meal moth, though varying in size, usually having a wingspread of about 1 inch. Its forewings are marked in a characteristic pattern, indicated in figure 22; they are light brown with dark-brown patches at the base and tip, and each has two wavy transverse white lines. The meal moth is widely distributed and is a general feeder in the larval stage upon cereals, cereal products, hay, and many types of dried vegetable matter. It is usually found in damp basements or in other places where accumulations of damp,

spoiled grain, bran, or meal are found. While preferring material that is damp and in poor condition, the meal moth may attack and severely damage sound wheat or

The larvae are whitish and, when full-grown, attain a length of about 1 inch. The two larger larvae in figure 22 indicate the normal shape and show the contrast between the

BN 3079

Figure 22.—The meal moth: a, Pupa and (above) webbed mass of grain showing portion of a pupa protruding; b, two well-grown larvae with a smaller larva at right; c, two adult moths. Magnified about one and one-half times. The markings on the forewings easily distinguish this insect from other grain pests.

cereal products if these are stored in moist places or have a relatively high moisture content. This insect sometimes attracts much attention because of its capacity to web up and bind together seeds of various kinds. The larvae cut through burlap sackings and can damage sacks greatly when heavy infestations develop in sacked material. Figure 23 shows the characteristic webbing together of infested seeds—in this instance navy beans—and figure 24 shows the tendency for larvae to spin their whitish silken cocoons on the outside of grain sacks where the sacks touch one another. When the larvae cut sacks, the seeds fall out and lodge where the sacks touch one another. In such places the seeds are usually heavily infested.

black of the head and the first body segment and the white of the remainder of the body. Often the body of the larva is tinged with orange toward each end. The larvae spin peculiar tubes of silk in which are mixed particles of the food material. They rest in these tubes, which are very tough, and feed from the openings at the ends. When full-grown, the larvae leave the tubes, spin silken cocoons, also often covered with food particles, and transform to the pupae, from which later emerge the adult moths. The female moths live for about a week and lay between 200 and 400 eggs. The developmental period from egg to adult in summer requires from 6 to 8 weeks.

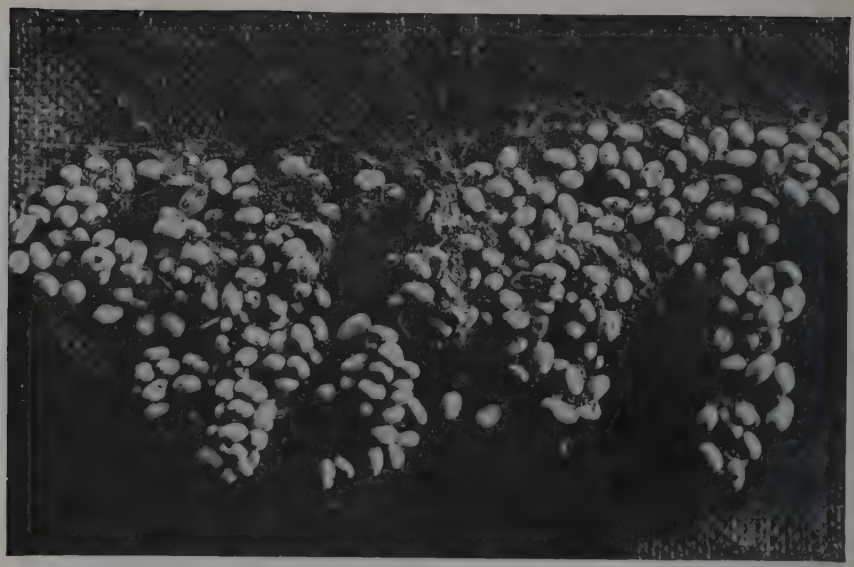


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Figure 23.—Navy beans webbed together by larvae of the meal moth and adhering to sack.

BN-3118

Figure 24.—The outside of a grain sack that was filled with infested vetch seed. Note vetch seed sticking to the side of the bag as a result of the webs of the larvae of the meal moth, the numerous whitish cocoons with dark pupae within, and, in the center, one adult moth.

GRAIN AND FLOUR BEETLES

Cadelle

The cadelle (*Tenebroides mauritanicus* (L.)) is an elongate, oblong, flattened, black or blackish beetle about one-third of an inch long (fig. 25). It is sometimes

BN–5081

Figure 25.—The cadelle. This beetle is about one-third of an inch long.

called the bolting-cloth beetle because of its habit of cutting the silk cloths of bolting reels and redressing machines in flour mills.

The larva of the cadelle is one of the largest of the grain-infesting insects and is easily recognized. It is about three-fourths of an inch long, fleshy, with the abdomen terminating in two dark horny points. The larva is a dirty or chalky white, with head, thoracic shield, and the two horny points at the end of the body black.

This insect is widespread over the world and is frequently found in mills, granaries, and storehouses, where it infests flour, meal, and grain. Both larva and adult feed on grain and have the destructive habit of going from kernel to kernel and devouring the germ. The cadelle is one of the longest-lived of the insects that attack stored grain; many of the adults live for more than a year and some of them for nearly 2 years. The female beetles oviposit during the greater part of their lives and under favorable conditions will lay about 1,000 eggs each.

The white eggs are laid in clusters in the food material and hatch in from 7 to 10 days in warm weather. The larvae complete their growth in from 2 to 14 months, then seek some secluded place in which to transform to the pupal stage (fig. 26), frequently boring into the timbers of the bin or other receptacle that holds the infested material. Both larvae and adults can live for considerable periods without food, frequently remaining hidden in the woodwork of the bins for a long time after the grain has been removed. When new grain is put into such a bin it becomes infested in a surprisingly short time.

Saw-Toothed Grain Beetle

The saw-toothed grain beetle (*Oryzaephilus surinamensis* (L.)) is one of the best-known of the cosmopolitan grain pests. A slender, flat, brown beetle about one-tenth of an inch long, it gains its name from the peculiar structure of the thorax, which bears six saw-tooth-like projections on each side (fig. 27). It attacks in both its larval

and adult stages all food of vegetable origin, especially grain and such grain products as flours, meals, breakfast foods, stock and poultry feeds, copra, nut meats, candies, and dried fruits.

Figure 26.—Larvae and pupae of the cadelle: The larvae (*a*) are shown in the galleries they have made in a piece of timber, and the pupae (*b*) in cells hollowed out where two boards were in contact.

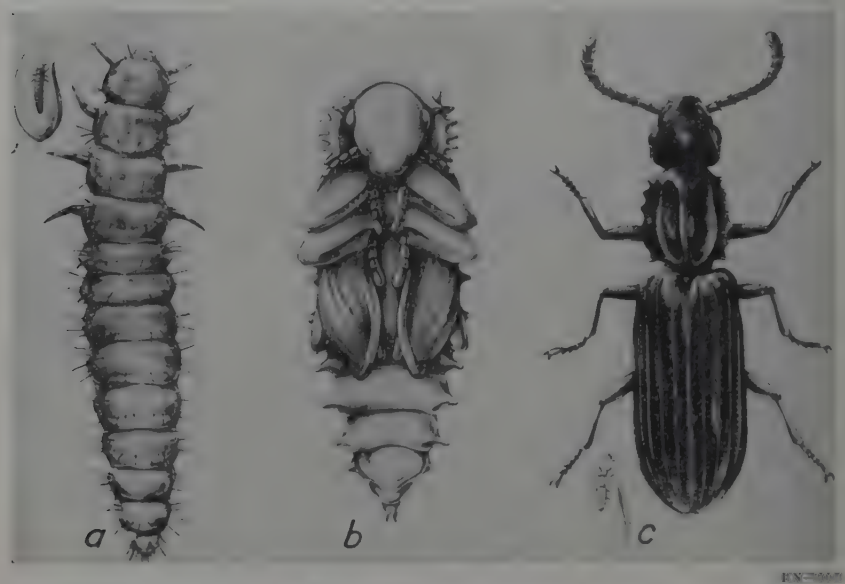

Figure 27.—The saw-toothed grain beetle: *a*, Well-grown larva; *b*, pupa; *c*, adult beetle. The adult beetle is about one-tenth of an inch in length. Beside the larva and adult are shown grains of wheat with the relative size of the insect indicated on them.

The adults live, on an average, from 6 to 10 months, but some individuals may live as long as 3 years. The female beetles have been known to lay from 43 to 285 eggs, dropping them loosely among the foodstuff or tucking them away in a crevice in a kernel of grain. The small, slender, white eggs hatch in from 3 to 5 days. The emerging larvae do not spend their lives within a single grain, but crawl about actively, feeding here and there. They become full-grown (fig. 27, *a*) in about 2 weeks during summer weather and then construct delicate cocoonlike coverings by joining together small grains or fragments of foodstuffs with a sticky secretion. Within this cell the larva changes to the pupal stage, which lasts about a week. Development from egg to adult may take place in from 3 to 4 weeks in summer.

Square-Necked Grain Beetle

The square-necked grain beetle (*Cathartus quadricollis* (Guér.)), is closely related to the saw-toothed grain beetle, which it greatly resembles in form, size, and color. It is a flattened, oblong, polished, reddish-brown beetle about one-tenth of an inch long. It differs from the saw-toothed grain beetle by having the thorax almost square and in lacking the saw-toothlike projections (fig. 28).

This beetle is abundant chiefly in the South, where it is found in great numbers outdoors infesting the seed pods of a great variety of plants. It is one of the most common beetles in stored corn in the South and in the cornfields is always to be found on damaged or exposed ears. The immature stages closely resemble those of the preceding species both in form and in habit. The larvae have the bad habit of devouring the germ of the seed in which they breed. They can develop from egg to adult in about 3 weeks.

BN-3085

Figure 28.—The square-necked grain beetle. The adult beetle is about one-tenth of an inch long.

Foreign Grain Beetle

The foreign grain beetle (*Ahasverus advena* (Waltl)) is a small reddish-brown beetle somewhat similar in appearance to the preceding species, to which it is closely related. It differs from it by being shorter and stouter (fig. 29).

BN-3086

Figure 29.—The foreign grain beetle.

Although of world-wide distribution, it is of little consequence as an enemy of stored grains. It is attracted to damp and moldy grains and feeds on the molds developing in such grains. It is rarely found in clean grain.

Mexican Grain Beetle

The Mexican grain beetle (*Pharaxonotha kirschi* Reit.) (fig. 30) is a highly polished, deep-brown beetle about three-sixteenths of an inch long. While resembling somewhat the confused flour beetle in general appearance, it can be readily distinguished by its more polished surface and by its longer antennae.

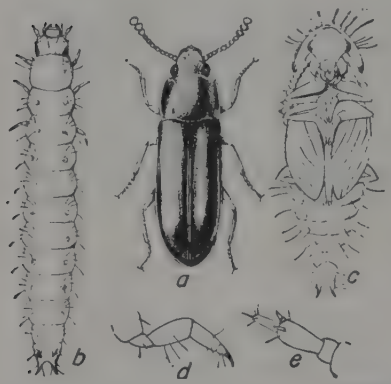

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Figure 30.—The Mexican grain beetle: *a*, Beetle; *b*, larva; *c*, pupa; *d*, leg of larva; *e*, antenna of larva. *a*, *b*, *c*, enlarged about 8 times; *d*, *e*, greatly enlarged.

This insect is common in Mexico and Guatemala, where it breeds in grain and grain products. It was found in this country in grain exhibits at the World's Fair (Columbian Exposition) in 1893, but it is not known to be permanently established in this country as yet. It may be found in grain in the extreme South.

Siamese Grain Beetle

The Siamese grain beetle (*Lophocateres pusillus* (Klug)) is a flattened, reddish-brown beetle slightly less than an eighth of an inch long, characterized by the much flattened margins of the thorax and wing covers (fig. 31).

First appearing in this country in exhibits of rice and cereals from Siam, Liberia, and Ceylon at the Columbian Exposition, it is now well-established in the Southern States. It is commonly found in rice mills in Texas but does not cause serious damage.

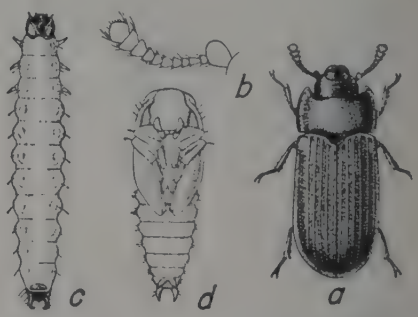

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Figure 31.—The Siamese grain beetle: *a*, Beetle; *b*, antenna of same; *c*, larva; *d*, pupa. *a*, *c*, *d*, about 10 times natural size; *b*, about 30 times natural size.

Flat Grain Beetle

The flat grain beetle (*Cryptolestes pusillus* (Schönherr)) (fig. 32) is one of the smallest beetles commonly found in stored grain. It is a minute, flattened, oblong reddish-brown beetle about one-sixteenth of an inch long, with elongate antennae about two-thirds as long as the body. It is cosmopolitan in distribution and is one of the commonest insect pests of stored grain. It is not a primary pest of stored grain, however, and

the adult is apparently unable to survive in sound, uninjured grain. It follows up the attack of the more vigorous grain pests and is frequently found in enormous numbers associated with the rice weevil. It is a scavenger by nature and often infests grain and meal that is out of condition.

The small white eggs are placed in crevices in the grain or dropped loosely in farinaceous material.

BN-3089

Figure 32.—Adult of the flat grain beetle, showing characteristic long antennae. Body not more than one-sixteenth of an inch long.

The larvae are particularly fond of the germ in wheat, and in infested grain many kernels will be found uninjured except for the removal of the germ. The larvae also feed on dead insects. When fully grown, the larvae form cocoons of a gelatinous substance to which food particles adhere. They transform to the pupal stage in these cocoons and later emerge as adults. Under favorable conditions this insect may complete its development from egg to adult in about 5 weeks, although the average length of the developmental period in summer is about 9 weeks.

A related beetle, *C. turcicus* (Grouv.), resembles the preceding species so closely in appearance and habit that it is usually confused with it. It also is cosmopolitan in distribution. The females of the two species are so much alike that it is almost impossible to distinguish between them. The males, however, can be distinguished by the length of the antennae. In *C. turcicus* the antennae of the male beetles are as long as or longer than the body, whereas in *C. pusillus* the antennae of the males are only two-thirds the length of the body.

Rusty Grain Beetle

A third species, *Cryptolestes ferrugineus* (Steph.), known as the rusty grain beetle, is similar to the two preceding species in appearance and habit, but differs in that the antennae of the male beetle are not more than half as long as the body. This species is more resistant to cold weather than the other two species and is more commonly found in stored grain in the Northern States.

Confused Flour Beetle

The confused flour beetle (*Tribolium confusum* Jacq. duVal) (fig. 33) is a shiny, reddish-brown beetle about one-seventh of an inch long, flattened and oval, with head and upper parts of thorax densely covered with minute punctures and with wing covers ridged lengthwise and sparsely punctured between the ridges. It is generally distributed over the world and is very abundant in all parts of this country. It is a general feeder on farinaceous material and is undoubtedly the most abundant and injurious insect pest of flour mills in the United States. It is found in granaries, mills, warehouses, and wherever grain or grain products are stored.

The average life of the beetles is about 1 year, but some have been known to live as long as 3 years 9 months. The females lay an average of about 450 eggs each. The small white eggs are laid loosely in flour or other food material in which the adults are living. They are covered with a sticky secretion and thus become covered with flour or meal, and readily adhere to the sides of sacks, boxes, and other containers, so that fresh material placed in them is rapidly infested. The eggs hatch in from 5 to 12 days into small wormlike larvae, slender, cylindrical, and wiry in appearance. When fully grown they are about three-sixteenths of an inch long, and are white, tinged with yellow. These larvae feed on flour or other material such as grain dust and the broken surfaces of grain kernels. When full grown they transform to small naked pupae. At first white, the pupae gradually change to yellow and then brown, and shortly afterwards transform to beetles. The period from egg to adult in summer averages about 6 weeks under favorable weather conditions, though the life cycle is greatly prolonged by cold weather, as is true of all grain pests.

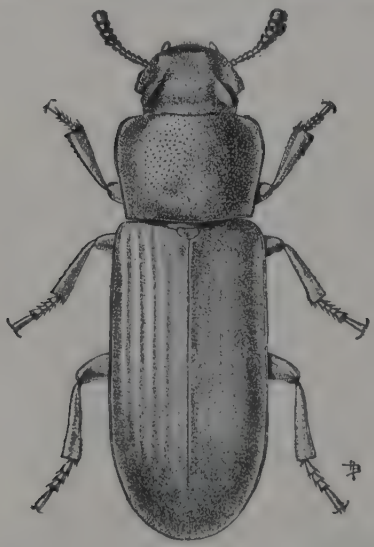

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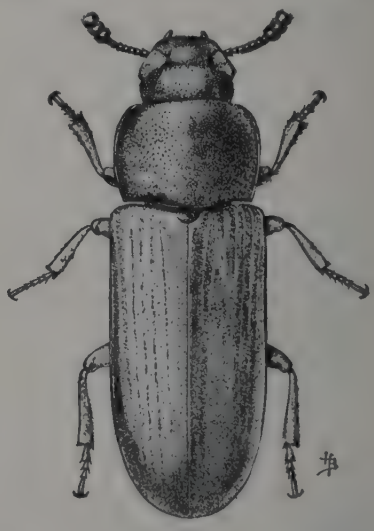
Figure 33.—The confused flour beetle, about one-seventh of an inch long.

Red Flour Beetle

The red flour beetle (*Tribolium castaneum* (Hbst.)) is almost identical in appearance with the preceding species, to which it is closely related. It can be distinguished from the confused flour beetle only with the aid of a magnifying glass. The segments of the antennae of the confused flour beetle increase in size gradually from the base to the tip, whereas in the red flour beetle the last few segments of the antennae are abruptly much larger than the preceding ones, giving the antennae the appearance of being suddenly enlarged at the tip. In addition, the margins of the head of the confused flour beetle are expanded and notched at the eyes, whereas the margins of the head of this species are nearly continuous



BN 3091

Figure 34.—The red flour beetle, about one-seventh of an inch long.

at the eyes. The differences between the two species are clearly shown in figures 33 and 34. This insect is constantly found associated with the confused flour beetle and has similar feeding and breeding habits. The immature stages of the two insects are so nearly alike that it is impossible to distinguish between them. The developmental period from egg to adult is usually somewhat shorter than for the preceding species. Although cosmopolitan in distribution, the red flour beetle is found more commonly in the South, where it causes very serious damage to grain products. In addition to the actual damage caused by its feeding activities, it imparts a nauseous smell and taste to the material it infests. Like the confused flour beetle, the red flour beetle is primarily a pest of milled products. It is present in grain shipments, but it confines its attack in these to grain dust and the surface of broken grains, hence is not a primary pest of commercial shipments.

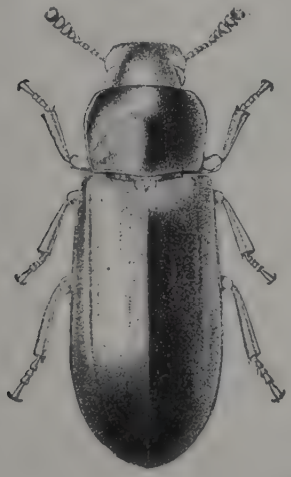


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Figure 35.—The black flour beetle, about one-sixth of an inch long.

Black Flour Beetle

The black flour beetle (*Tribolium madens* (Charp.)) (fig. 35), is another species of the genus *Tribolium* that occurs in the United States. Not so well known as the two preceding species, it has similar habits and is occasionally found infesting grain and grain products in flour mills and storehouses. It is seldom found in injurious numbers and is by no means as widespread as *T. confusum* and *T. castaneum*. It occurs in its greatest abundance in the States of the Rocky Mountain region, but it has been reported from widely scattered points over the country. It may be readily distinguished from the confused and red flour beetles by its being black and by its larger size. It is about one-sixth of an inch in length. *T. destructor* Uyttenb., another species of this destructive group of flour beetles, has recently been reported from Montreal, Canada, infesting poultry feed. It is an introduction from Europe.

BN–3093

Figure 36.—The long-headed flour beetle, about one-eighth of an inch long.

Long-Headed Flour Beetle

The long-headed flour beetle (*Latheticus oryzae* Waterh.) (fig. 36) is a slender, flattened beetle, slightly less than an eighth of an inch long, somewhat similar in form to the confused flour beetle but narrower and pale yellowish brown. It is further differentiated by the peculiarly shaped antennae and by the minute canthus behind each eye. It has been reported from most parts of the world as infesting wheat, rice, corn, barley, rye, flour, and similar products. It was first recognized in this country from specimens collected in Texas in 1908. It is now widespread in the Southern and Middle Western States, where it is common in rice and flour mills, infesting grain and grain products and causing the same type of damage as does the confused flour beetle.

Broad-Horned Flour Beetle

The broad-horned flour beetle (*Gnathocerus cornutus* (F.)) owes its name to the peculiar structure of the mandibles, or jaws, of the male beetle, which are armed with a pair of broad, stout horns, as shown in figure 37. It is a stout, reddish-brown beetle, about one-sixth of an inch long, closely resembling the other flour beetles in appearance, but easily distinguished by the peculiar structure of the jaws. It is cosmopolitan in distribution and is common in all parts of the United States except in the Great Plains, where it is comparatively rare. It prefers to feed in flour and meal, but is found in a variety of grains. The adult beetles frequently live for a year or longer; the females laying from 100 to 200 eggs each. The small white eggs hatch in from 4 to 6 days in warm weather, and development from egg to adult takes place in from 6 to 8 weeks.

Slender-Horned Flour Beetle

The slender-horned flour beetle (*Gnathocerus maxillosus* (F.)) is

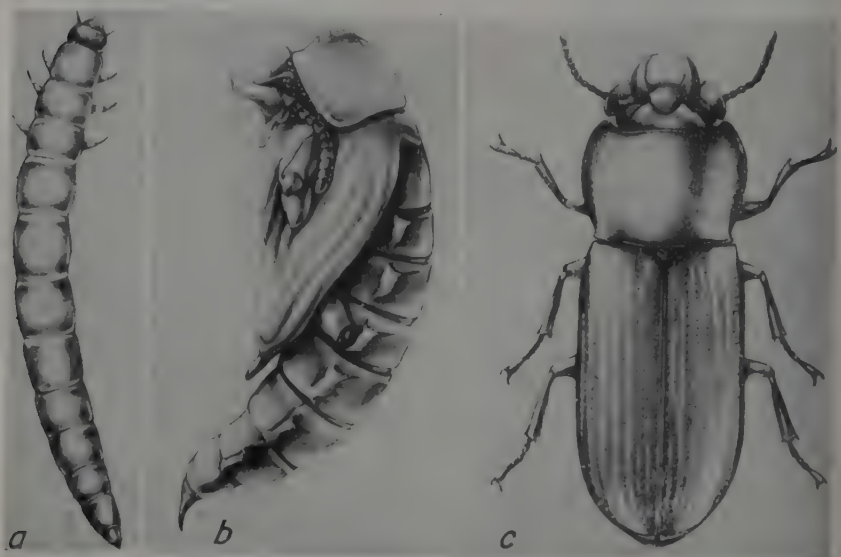

Figure 37.—The broad-horned flour beetle; *a*, Larva; *b*, pupa; *c*, adult. The beetle is about one-sixth of an inch long.

closely related to the preceding species and is of similar form and appearance. It is about one-eighth of an inch in length. In addition to its smaller size, it may be distinguished from the broad-horned flour beetle by the shape of the horns with which the mandibles or jaws of the male are armed. In this species (fig. 38) the horns are

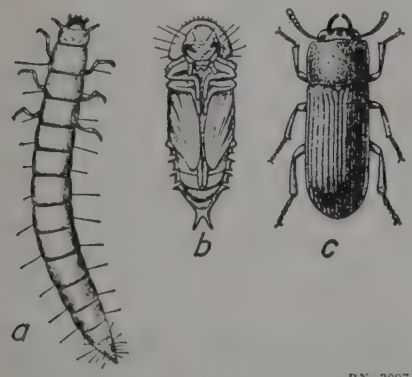

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Figure 38.—The slender-horned flour beetle: *a*, Larva; *b*, pupa; *c*, beetle. The beetle is about one-eighth of an inch long.

slender and incurved. Its habits are similar to those of the preceding species. It is less common in the United States than *G. cornutus* and is more or less confined to the Southern States.

Small-Eyed Flour Beetle

The small-eyed flour beetle (*Palorus ratzeburgi* (Wissm.)) is the smallest of the so-called flour beetles that infest grain and grain products in this country. It is a tiny, flattened, shiny, reddish-brown beetle, somewhat oblong in form and measuring about one-tenth of an inch in length. It occurs throughout the world and is widely distributed in this country. It breeds in grain and milled products and is frequently found in flour-mill basements.

Depressed Flour Beetle

The depressed flour beetle (*Palorus subdepressus* (Woll.)) is very similar in appearance and habits to the small-eyed flour beetle. It may be distinguished from this species by its slightly larger size and by the fact that the sides of the front of the head are strongly reflexed and extend backward, concealing the front portion of the eye. In the small-eyed flour beetle the sides of the front do not extend backward. The depressed flour beetle, also, is cosmopolitan in distribution but is much less common in the United States than *P. ratzeburgi* except perhaps in the Great Plains.

Larger Black Flour Beetle

The larger black flour beetle (*Cynaeus angustus* (LeC.)) (fig. 39), described in 1852, was little known as a pest of stored grain and grain

Figure 39.—The larger black flour beetle. Actual length about one-fourth inch.

products until 1939, when it was found in a flour mill in Seattle, in stored wheat in Kansas, and in stored corn in Iowa. It is now fairly common in farm-stored grain in the North Central States. It is a stout, reddish-brown or black beetle about ¼ inch in length. It has been observed to live for 6 months and may live for at least a year under favorable conditions. The life cycle from egg to adult can be completed in 4 weeks, but is usually from 6 to 10 weeks. It prefers grain that is high in moisture.

EGGS OF FLOUR AND GRAIN INSECTS

The eggs of the common flour- and grain-infesting insects are rarely seen by the layman. They are usually white in color and are often covered with a sticky substance that causes particles of flour or other material to adhere to them, thus making them difficult to distinguish from the foodstuff in which they are deposited. Some are oval or oblong-oval, while others are slender and spindle shaped. Their small size is well illustrated in figure 40, in which is shown a group of eggs of four different species of insects resting on a piece of 10XX silk bolting cloth. The eggs of the flat grain beetle are so small that if placed side by side they would average about 150 to the inch. Those of the cadelle, which is one of the larger beetles in-

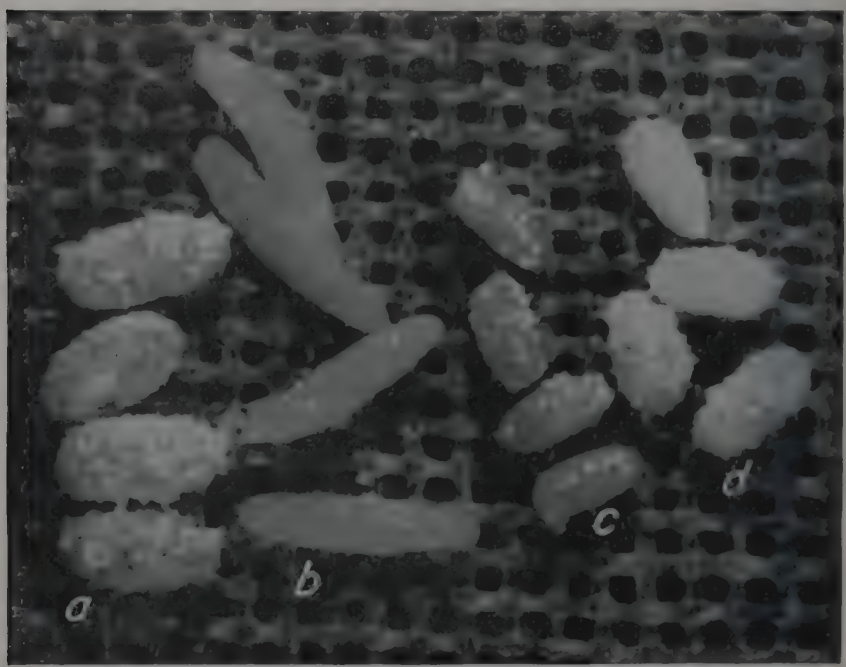


Figure 40.—Eggs of flour and grain insects shown resting on a piece of 10XX bolting cloth: *a*, Broad-horned flour beetle; *b*, cadelle; *c*, Mediterranean flour moth; *d*, confused flour beetle. Greatly enlarged.

festing stored cereal products, if laid end to end, would average about 19 to the inch. During the process of milling flour and preparing it for the market it is sifted through silk bolting cloth to remove insect eggs and other impurities.

MEALWORMS

The term "mealworm" is applied to the larvae of several beetles of the family Tenebrionidae that are nocturnal in habit and frequent dark places. They breed in refuse grain and coarse cereal and mill products that accumulate in dark corners, under sacks, in bins, and in similar places. They are fond of moist situations and are often found among bags that are slightly damp.

Yellow Mealworm

The yellow mealworm (*Tenebrio molitor* L.) (fig. 41) is one of the largest of the insects that infest stored cereal products. It is cosmopolitan in distribution, but, although found occasionally in all parts of the country, it is abundant only in the Northern States.

The adult is a polished dark-brown or black beetle, somewhat more than half an inch long. Its thorax is finely punctured and its wing covers are longitudinally striated or grooved. The females lay bean-shaped white eggs covered with a sticky secretion that causes the flour, meal, or grain waste in which they are placed to adhere to them. The eggs hatch in about 2 weeks into slender white larvae, which soon turn yellow and assume the form shown in figure 41. When full-grown, the larvae are about an inch long and yellowish, shading to yellowish brown toward each end and at the articulation of each segment. It is to the yellow color of the larva that this insect owes its name of "yellow mealworm."

There is but one generation each year. The adults begin to appear in the latitude of Washington, D. C., in the latter part of May and early in June and may be found until late in August. The female beetles are quite prolific and may lay as many as 500 eggs each. The larvae become full-grown in about 3 months, but instead of transforming then to the adult stage they continue feeding and molting until cold weather and then hibernate as larvae. In late spring or early summer of the following season they transform to the pupal stage, in which stage the insect passes about 2 weeks. Because the yellow mealworm has but one generation each year and is entirely an external feeder upon grains, it need not be feared as a serious pest. Screening and fanning will remove it easily from grain shipments. The well-grown larvae, however, can do serious injury to whole grains under certain conditions when grain is held for long periods without being moved.

Dark Mealworm

The dark mealworm (*Tenebrio obscurus* F.) is very similar in form, size, and color to the yellow mealworm, to which it is closely related. The adult beetle differs, however, in being dull pitchy black, in contrast to the shiny or polished dark brown or black of the yellow mealworm. Its larva so closely resembles the larva of the yellow mealworm that it can be distinguished most easily by its much darker color.

The two species of mealworms are often found associated, since they have similar feeding habits. The overwintering larvae of the dark mealworm begin to pupate earlier in the season than the yellow mealworms, and, in the vicinity of Washington, D.C., the adult beetles emerge during April and May.

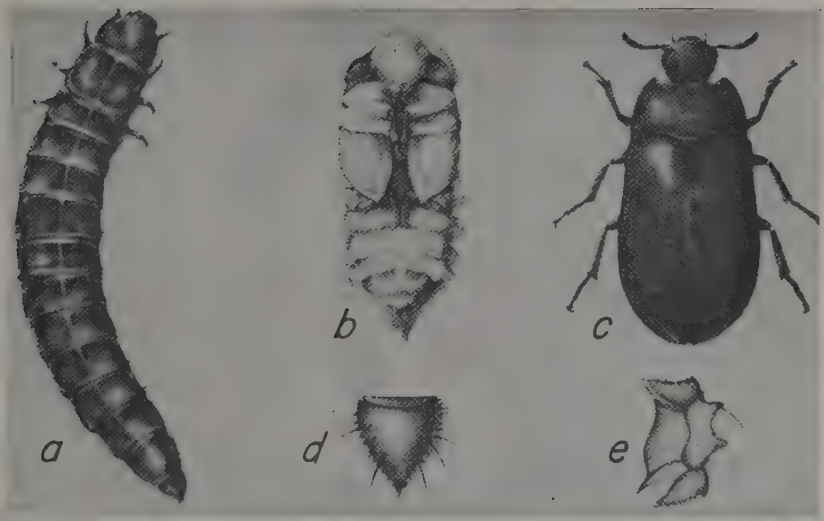
Lesser Mealworm

The lesser mealworm (*Alphitobius diaperinus* (Panz.)) resembles the two preceding species in form and color but is considerably smaller. It is black or a very dark reddish brown and measures from three-sixteenths to four-sixteenths of an inch in length. The larva is yellowish brown and closely resembles young larvae of the yellow mealworm in form and appearance. It is cosmopolitan in distribution and is commonly found in flour-mill basements in damp or musty flour or grain. It prefers grain and cereal products that are slightly out of condition.

Black Fungus Beetle

The black fungus beetle (*Alphitobius laevigatus* (F.)) (fig. 42) is almost identical in appearance with the lesser mealworm and has similar

Figure 41.—The yellow mealworm. Four well-grown larvae, two pupae, and the black adult beetle, with five kernels of wheat to indicate relative size. The larvae when full-grown are about 1 inch long and yellowish. The adult beetles are slightly more than half an inch long.



BN–3100

Figure 42.—The black fungus beetle: *a*, Larva; *b*, pupa; *c*, adult; *d*, caudal segment of larva; *e*, lateral plate of pupa. The larva is about 1 inch long.

habits. It prefers grain and cereal products that are damp and moldy and does not cause serious damage to sound grain. It may be distinguished from the preceding species by the fact that the sides of the thorax are curved and the surface coarsely and profusely punctured, whereas in the lesser mealworm the sides of the thorax are nearly straight and the surface finely and sparsely punctured. In the United States it is much less abundant than the lesser mealworm.

Red-Horned Grain Beetle

The red-horned grain beetle (*Platydema ruficorne* (Sturm)) (fig. 43), is a broadly oval beetle, slightly less than ¼ inch long. It is velvety black with a purplish tinge, and with reddish-yellow antennae. Reported as common on fleshy fungi and beneath the bark of trees, it was found in abundance in shelled corn in Missouri in 1940 and commonly in shelled corn in Illinois and Iowa. It is particularly attracted to damp and moldy grain.

Figure 43.—The red-horned grain beetle. About one-fourth inch long.

DERMESTID BEETLES

The dermestids are a group of beetles that in general are scavengers and feeders on animal matter. Certain species, however, belonging to the genera *Trogoderma*, *Anthrenus*, and *Attagenus* have acquired the habit of varying their diet by feeding at least in part on farinaceous materials. They are of frequent occurrence in flour mills, farm granaries, warehouses, and similar places where grain and grain products are stored.

BN-3101

Figure 44.—Larva of the black carpet beetle. The larva, including the tuft of hairs, is about two-fifths inch long.

Black Carpet Beetle

The black carpet beetle (*Attagenus piceus* (Oliv.)) is a small oval beetle between two-sixteenths and three-sixteenths of an inch long. The head and thorax are black, but the wing covers may be either black or dark reddish brown, and clothed with short hairs. Its legs and antennae are dark yellow. The larva is very characteristic and can be readily recognized. It is reddish or golden brown, clothed with short, scalelike, appressed hairs and provided with a tuft of long hairs at the end of the body, as shown in figure 44.

The larvae are often to be found in abundance living in cracks in the floors of warehouses where foodstuffs have accumulated. In the spring these larvae transform to adults, which swarm over bagged material stored there. The larvae of the black carpet beetle develop slowly, so that there is only one generation a year. If conditions are unfavorable, the life cycle may be prolonged to 2 or 3 years. The adults, which emerge in the spring and early part of the summer, live from 2 to 4 weeks, and the females may lay about 100 eggs. This beetle is cosmopolitan in distribution.

Khapra Beetle

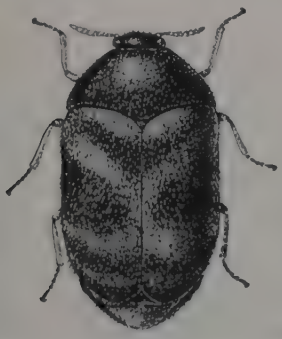
The khapra beetle (*Trogoderma granarium* Everts) (fig. 45) was discovered in Tulare County, Calif., in 1953 and is thought to have been present in the San Joaquin Valley since 1939. Before its discovery it had spread to other points in California, and into Arizona, New Mexico, Texas, and Baja California, Mex. A Federal quarantine was invoked in February 1955 to deter the spread of this pest to other areas, and an eradication program was begun. This program has reduced the number of known infestations to a very few points in Arizona, Southern California, and Baja California.

The adult beetle is small, averaging one-fourteenth to one-eighth of an inch in length. The females are often about twice the size of the males. The beetle is pale red-brown to dark brown or black; its

wing covers are unicolorous or have indistinct red-brown markings. Often the hairs on the top of the beetle are rubbed off, giving it a slick appearance. Its small size and immaculate or only vaguely maculate elytra distinguish it from other species of this group.

The larva (fig. 46) is yellowish-brown and clothed with long hairs; the integument between the segments, as well as the underside of the body, is pale yellow. The young larva is about one-sixteenth of an inch long. As it matures it increases in length to about one-sixth of an inch. It is difficult to distinguish between larvae of this species and related species.

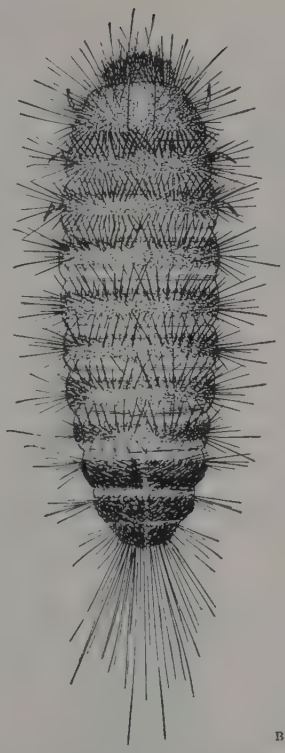
Adult female beetles lay up to 126 eggs each. The life cycle varies in length from 4 to 6 weeks to several years, depending upon the temperature and the food supply. In India it is said that there may be as many as 12 generations a year. The larvae are highly resistant to starvation; they may live for months or even years without food.



BN 3051

Figure 45.—Adult of the khapra beetle.

The khapra beetle is a dermestid. It prefers dried vegetable matter to animal matter as food, but will attack almost any kind of either material. Grain damaged by the khapra beetle has somewhat the same appearance as grain attacked by the lesser grain borer.



BN—3502

Figure 46.—Larva of the khapra beetle.

Under favorable conditions the khapra beetle breeds so rapidly that the larvae often appear in enormous profusion in the surface layers of binned grain. The larvae have the habit of crowding into crevices of buildings, bins, etc., and are difficult to reach with insecticides. As this beetle has poor powers of locomotion, it is spread principally through the agency of man.

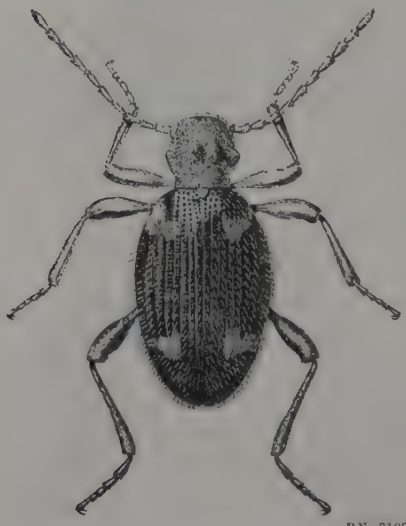
Other species of dermestids that occur in this country and are likely to be confused with it are *T. inclusum* LeC., *T. glabrum* (Hbst.), *T. grassmani* Beal, *T. ornatum* (Say), *T. parabile* Beal, *T. simplex* Jayne, *T. sternale* Jayne, and *Anthrenus verbasci* (L.). Of this group the best known is *T. inclusum*, which is a common pest of seed in the Great Plains States.

SPIDER BEETLES

Several species of beetles belonging to the family Ptinidae are occasionally found infesting grain and cereal products and attract attention by their peculiar spiderlike form. They are rather widespread in distribution but are rarely abundant enough in the United States to cause serious damage.

Hairy Spider Beetle

The hairy spider beetle (*Ptinus villiger* (Reit.)) (fig. 47) is a red-



BN—3102

Figure 47.—The hairy spider beetle. This beetle is about one-seventh of an inch long.

dish-brown beetle marked with four irregular white patches. It is about one-seventh of an inch long. It is a rather common pest in the prairie Provinces of Canada and is occasionally destructive in the adjoining Northern States. It attacks stored grain and all types of ground cereal products. The adult beetles appear in warehouses in the spring and lay their eggs in flour, feed, or other cereal products. The female beetles have been observed to lay about 40 eggs. Under favorable conditions development from egg to adult takes place in about 3½ months. The full-grown larvae construct characteristic pupal cases of a silky material covered with particles of the food material in which they occur.

An allied species, *P. raptor* Sturm, is about as common in Canada as *P. villiger*.

White-Marked Spider Beetle

The white-marked spider beetle (*Ptinus fur* (L.)) (fig. 48) is also found in the Northern States and is somewhat more abundant than the preceding species, which it resembles closely in appearance and habits. It is an omnivorous feeder, attacking flour, feed, grain, and miscellaneous foodstuffs. It is rarely abundant enough to cause serious damage.

BN—3103

Figure 48.—The white-marked spider beetle, adult female. (The male is elongate oval and is not so conspicuously marked as the female.)

Brown Spider Beetle

The brown spider beetle (*Ptinus clavipes* Panzer) closely resembles the preceding species in size, color, general appearance, and habits. It may be distinguished from the white-marked spider beetle by the fact that the white markings of the wing covers are lacking.

Other Spider Beetles

The Australian spider beetle (*Ptinus ocellus* Brown) has been reported from the United States but is rarely found here. It is very similar in general appearance and habits to the preceding species.

Mezium americanum (Laporte) (fig. 49) is a small spider beetle of striking appearance. It has a shining subglobular body that distinguishes it from the preceding species. It appears to be somewhat of a scavenger, feeding on dried animal products as well as on organic material. It is not important as a pest of stored grain or grain products, but is occasionally found in mills, warehouses, and dwellings. A closely related species, *Gibbium psylloides* (Czenp.), resembles it closely in appearance and habits and is found in similar situations. It may be distinguished from it by the fact that the head and thorax are entirely bare while in *M. americanum* the head and thorax are densely covered with small scales and scalelike hairs. This species is said to occur only in the extreme southern portion of the United States whereas *M. affine* Boield. is the common form in the Northern States and in Canada.

BN -3053

Figure 49.—*Mezium americanum*, adult beetle. Enlarged.

MISCELLANEOUS BEETLES

Two-Banded Fungus Beetle

The two-banded fungus beetle (*Alphitophagus bifasciatus* (Say)) is a handsome little elongate-oval beetle slightly less than an eighth of an inch long. It is reddish brown with two broad black bands across the wing covers. Its characteristic color pattern is shown in figure 50. It is distributed over the world and is in general a feeder on fungi and molds, being a scavenger in refuse grain and grain products, decaying vegetable matter, etc. It is frequently found around mills and storehouses where waste material is allowed to accumulate. The larvae have been reared from moist corn meal and in spoiled cereals. The insect is often found in the holds of grain ships in wet or damaged grain.

Hairy Fungus Beetle

The hairy fungus beetle (*Typhaea stercorea* (L.)) (fig. 51) is frequently found in cornfields where it is apparently attracted to decaying kernels of exposed ears. After corn is harvested and shelled it is often heavily infested by this insect, although little feeding on

undamaged grain is experienced. The beetle is cosmopolitan in distribution and is found in all parts of the United States in dwellings, warehouses, stores, flour mills, granaries, and similar places.

BN-3104

Figure 50.—The two-banded fungus beetle, adult. x 20.

BN-3054

Figure 51.—The hairy fungus beetle. Length about one-tenth inch.

It is a small brownish beetle about one-tenth of an inch long and covered with hairs. It rather closely resembles the drug-store beetle in general appearance, but is smaller. It can also be easily distinguished from the drug-store beetle by the shape of its antennae, which are clavate instead of being irregularly serrate.

Corn Sap Beetle

The corn sap beetle (*Carpophilus dimidiatus* (F.)) may be readily recognized by its peculiar wing covers, which are short and truncate, leaving the tip of the abdomen exposed, as shown in figure 52. It is a small, dark-brown beetle with

BN-3105

Figure 52.—The corn sap beetle, adult. Enlarged.

lighter colored wing covers, oblong-ovoid in shape, and ranging in length from one-tenth to one-eighth of an inch. It normally feeds in rotting and decaying fruit and vegetation and in the sap exuding from injured plants. It is quite numerous in cornfields in the South, swarming over the damaged ears and feeding and breeding in the decaying kernels. It is attracted to damp and decaying grain, and not infrequently is found in rice mills breeding in accumulations of broken rice. It is often seen in swarms crawling over bags of rice.

A closely related beetle (*Carpophilus* (*Urophorus*) *humeralis* (F.)) that has been introduced from abroad and is becoming more and more abundant, is similar in form to the corn sap beetle, but is slightly larger and is uniform, shiny, dark brown all over. Its habits are very similar to those of the preceding species.

Cigarette Beetle

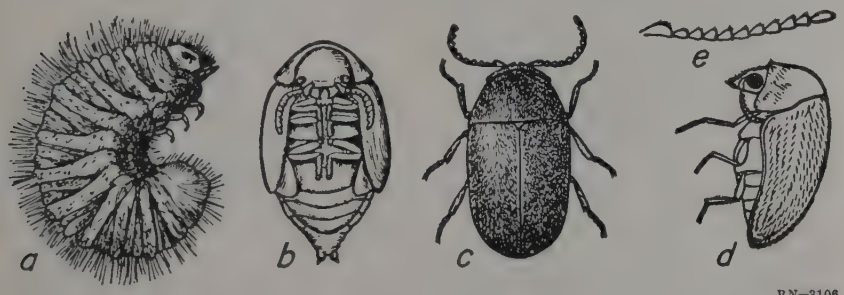
The cigarette beetle (*Lasioderma serricorne* (F.)) is a small, stout, oval, reddish-yellow or brownish-red beetle, with head bent down nearly at right angles to the body, giving the beetle a humped appearance when viewed from the side as shown in figure 53. It varies in size, but is usually about one-tenth of an inch long. It is found in all temperate, subtropical, and tropical regions and infests tobacco and many other stored products. It breeds in a variety of seeds and may occasionally be found attacking grains left long in storage in original sacks.

The adult beetles live from 2 to 4 weeks, and during this time the females may lay as many as 100 eggs. The developmental period from egg to adult is quite variable but under favorable conditions is from 6 to 8 weeks.

Drug-Store Beetle

The drug-store beetle (*Stegobium paniceum* (L.)) is very similar in appearance to the cigarette beetle, to which it is closely related, but differs from it by being more elongate in proportion and in having the wing covers distinctly striated. It is about one-tenth of an inch long, cylindrical, and uniform light brown, its body covered with a fine silky pubescence (fig. 54). The larva, or grub, is very much less hairy than that of the cigarette or tobacco beetle. It is known as the drug-store beetle from its habit of feeding on almost all drugs found in pharmacies. It is a very general feeder, attacking a great variety of stored foods, seeds, and other materials, and has been said to "eat anything except cast iron." It is frequently found in storehouses and granaries in all parts of the world.

The eggs of this beetle are laid in almost any dry organic substance. The small white grubs emerging from the eggs tunnel through these substances and when full grown pupate in small cocoons. The entire life cycle may be passed in less than 2 months.



BN—3106

Figure 53.—The cigarette beetle: *a*, Larva; *b*, pupa; *c*, beetle, dorsal view; *d*, beetle, side view; *e*, antenna of beetle. The beetle is about one-tenth of an inch long.

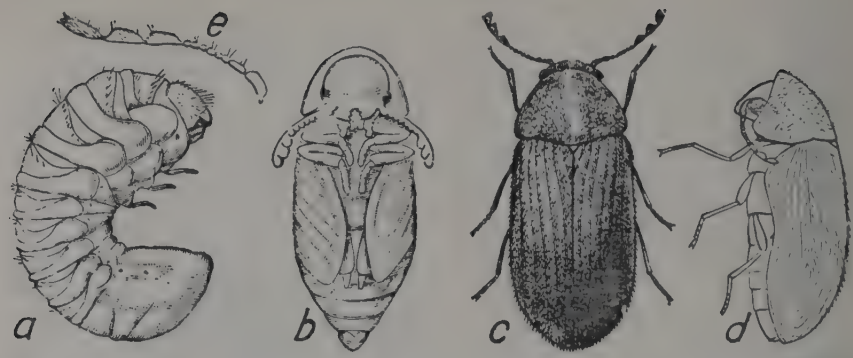


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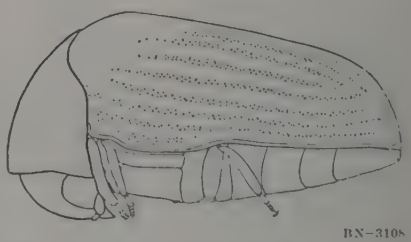
Figure 54.—The drug-store beetle: *a*, Larva; *b*, pupa; *c*, beetle, dorsal view; *d*, beetle, side view; *e*, antenna of beetle. This beetle is about one-tenth of an inch long. It never attacks grain unless the grain is stored for long periods undisturbed.

Catorama Beetle

Another beetle closely related to the drug-store beetle and the cigarette beetle and which has similar habits is the catorama beetle (*Catorama* sp.), which is shown in figure 55. It is shiny black and about one-eighth of an inch long. It is only an occasional pest of stored grain and does not cause serious damage.



BN-3108

Figure 55.—The catorama beetle. This beetle is about one-eighth of an inch long.

BOOKLICE OR PSOCIDS

Grain and grain products are sometimes found to be swarming with minute insects that are scarcely larger than a pinhead. Flour and grain samples appear to be particularly attractive to them. They are known as psocids, or booklice, owing to the resemblance to lice and their occasional presence in books. They belong to several closely related species of the genus *Liposcelis* (fig. 56). They are tiny, pale-grayish or yellowish-white, wingless, soft-bodied louselike insects with fairly large heads, poorly developed eyes, and long slender antennae. They are about one twenty-fifth of an inch in length. They feed on a great variety of organic matter, both of plant and animal origin, but are troublesome through their presence rather than for the actual damage they cause.

In some cases females are believed to reproduce without mating; in other cases males have been found. As many as 100 eggs may be laid by a single female, and in summer the developmental period from egg to the mature insect is about 3 weeks. The newly hatched young resemble the mature insects in form and general appearance but are

smaller and of a lighter color. These insects are widely distributed in North America and Europe.

A closely related species, *Trogium pulsatorium* (L.), known as the death watch, is similar in appearance and habits and is found under the same circumstances. It may be distinguished from the common booklouse by the fact that it is slightly larger, has a pair of diminutive wing covers, and has well-developed eyes. It also is widely distributed over North America and Europe but is not quite so common or abundant as the preceding species.

BN—3109

Figure 56.—Booklouse or psocid. Enlarged.

SILVERFISH

A rather common insect in mills, warehouses, and dwellings is a glistening, silver or pearly-gray insect known as a silverfish or slicker (*Lepisma saccharina* L.). The possession of three long taillike appendages gives it a characteristic appearance easily recognized. It is cosmopolitan in distribution and feeds on starchy foods of all kinds. It is found particularly in dark, moist, warm situations.

A closely related species, *Thermobia domestica* (Pack.), known as the firebrat, is shown in figure 57. It is found in similar situations and closely resembles the silverfish in appearance and habits. It may be differentiated from the silverfish by its broader body. It is pearly white, heavily mottled along the back, with dusky scales that give it a banded appearance when some of the scales have been rubbed off. It is cosmopolitan in distribution and in some places is more abundant than the silverfish. Development from egg to adult is completed in from 11 to 12 weeks.

BN—3110

Figure 57.—Adult firebrat, about two and one-fourth times natural size.

COCKROACHES

Cockroaches are of frequent occurrence in establishments handling cereal products, and everybody is familiar with their appearance. They are particularly abundant in the basements of buildings in dark, dark brown or black, measuring when full-grown about an inch long. The females are unique in that they have no functional wings—merely short wing pads. The males have fully developed wings.

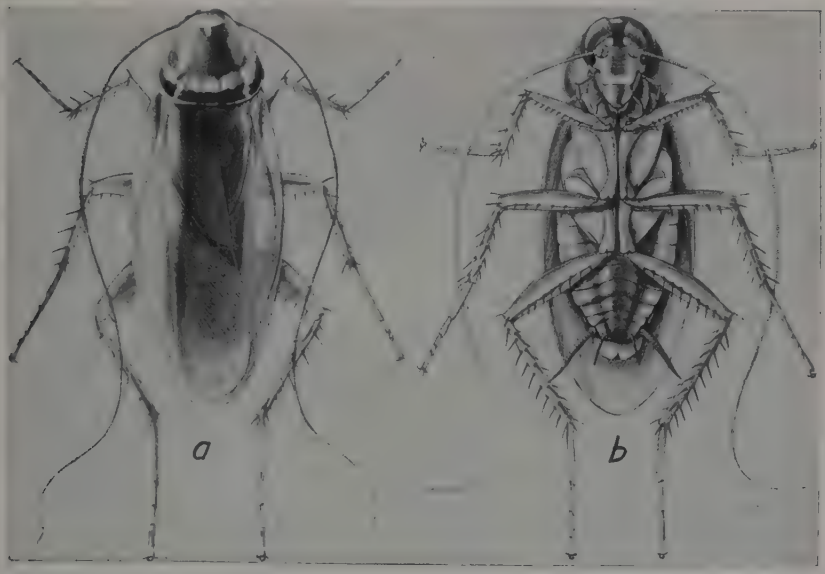
BN-3055

Figure 58.—The oriental cockroach: *a*, Female; *b*, male; *c*, side view of female; *d*, half-grown specimen. Enlarged.

moist situations, and when lights are suddenly turned on, it is not uncommon to see the floors of basements almost black with them. The oriental cockroach (*Blatta orientalis* L.) (fig. 58) is probably the commonest species found in flour mills and food establishments in North America. It is a large roach,

A closely related species, *Periplaneta americana* (L.), known as the American cockroach, is also quite abundant and in many flour mills in the Southwestern and Midwestern States is the predominant form. It is even larger than the oriental cockroach and frequently is 1½ inches in length. It is bright

sienna brown except for the pronotum, which is brownish yellow and encloses the characteristic, irregular-shaped, reddish-brown double spot in the center. It is shown in figure 59.



BN–3111

Figure 59.—The American cockroach: *a*, View from above; *b*, from beneath. Enlarged.

FLOUR OR GRAIN MITES

The flour or grain mites are pale, grayish-white, smooth, soft-bodied creatures, microscopic in size, and provided with numerous long hairs on the legs and back, as shown in figure 60. Mites are not true insects, as the adults have eight legs and the body is indistinctly divided into two parts. They have no wings. The flour or grain mites are much smaller than the booklice, being usually less than one-fiftieth of an inch in length. They are often found in stored grain and occasionally increase with such rapidity that the grain seems to be fairly alive with them. During heavy infestations their cast skins and dead bodies accumulate in fluffy light-brown masses beneath the sacks of grain. If these accumulations are on a warehouse floor, they roll up into piles, which are blown about with each gust of wind. No other group of pests in grain will produce these masses. When present in large numbers, they promote sweating, impart a disagreeable odor to the grain, and may cause damage by their feeding. Fortunately the mites that attack grain are themselves preyed upon by predacious mites, which usually become abundant enough to kill the grain mites in a comparatively short time. If they do not, the screening and fanning of grain will usually reduce mite infestations to a point where no injury takes place.

The most injurious species of mite found in flour, grain, and cereal products in North America is *Acarus siro* L., which is popularly

known as the flour mite, common forage mite, or grain mite. It multiplies with great rapidity under favorable conditions and may complete its life cycle from egg to mature mite in a little over 2 weeks.

Species of the genus *Tyrophagus*, and related genera, also known as flour mites or cheese mites, are common in grain. They are similar in appearance and habits to *A. siro*.

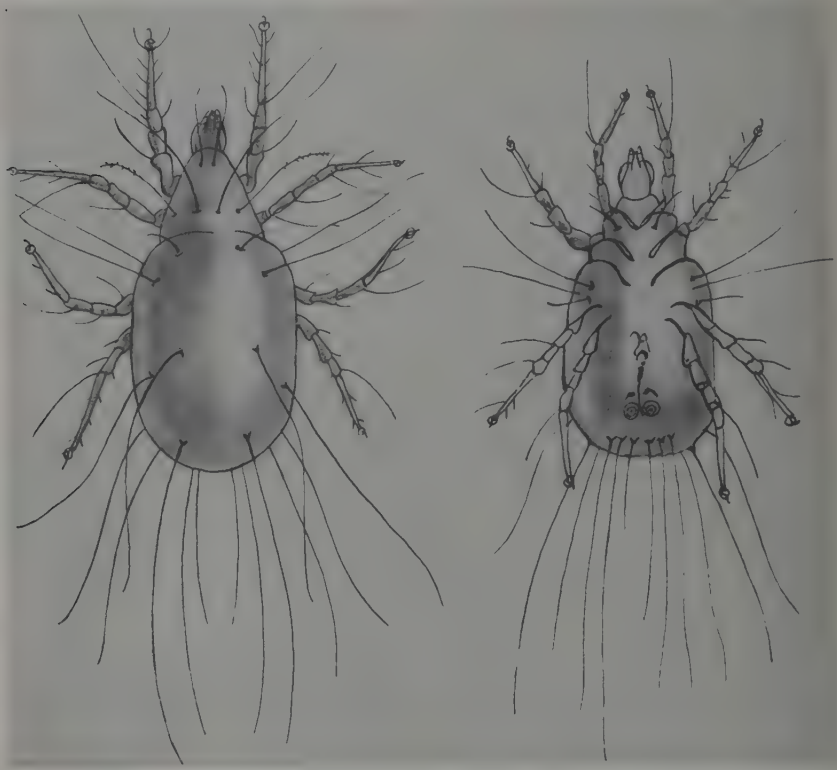


Figure 60.—Grain mites. Greatly enlarged.

PARASITES OF GRAIN PESTS

Grain in bulk is sometimes seen swarming with small wasplike creatures of the size and appearance shown in figure 61. Similar insects may also be seen on the windows of flour mills and other establishments where cereal products are handled. These insects are not harmful but beneficial in that they attack and destroy the insects that infest grain and grain products.

The small parasite shown resting on the kernel of wheat in figure 61 is the adult of *Anisopteromalus calandrae* (How.), the most important parasite of the rice and granary weevils. The female wasp is able to detect the presence of the grain weevil grub hidden from sight within the grain and paralyzes it with a few thrusts of the ovipositor. A single egg is then

deposited on the exterior of the grub or in close proximity to it. The egg hatches, and the parasite grub feeds on the paralyzed weevil grub, thus destroying it. The developmental period from egg to adult is about 2 weeks. A single female parasitic wasp has been observed to lay as many as 283 eggs, but the help usually comes too late to prevent damage to the crop.

Another fairly common parasite of the grain beetles is shown in figure 62. This parasite, *Cephalonomia tarsalis* (Ashm.), has habits quite similar to those of the preceding species.

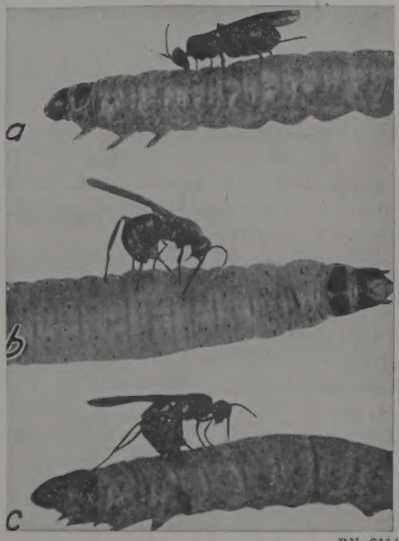
BN–3056

Figure 61.—*Anisopteromalus calandrae*, a hymenopterous parasite of grain pests, resting upon a kernel of wheat.

The adult of *Bracon hebetor* Say attacking larvae of one of the meal or flour moths is illustrated in figure 63. This little wasp is one of the most important parasites of these moths. It first paralyzes the flour moth caterpillar by stinging it several times. Then it places several eggs on the paralyzed caterpillar. These eggs hatch into small, white, footless, grublike larvae that suck the body juices of the caterpillar. Under favorable circumstances this parasite completes its development from egg to adult wasp again in less than 2 weeks.

BN–3113

Figure 62.—*Cephalonomia tarsalis*, adult. Enlarged.



BN–3114

Figure 63.—Female of *Bracon hebetor* in three poses: *a*, Feeding on the body fluids of a larva of the Mediterranean flour moth and showing the short, straight ovipositor protruding behind; *b*, the parasite in the position assumed in puncturing the body of the larva preparatory to laying an egg; *c*, the parasite with the ovipositor well inserted in the larva and about to lay the egg.

Another beneficial wasp that is of even greater importance as a parasite of the flour and meal moths is *Devorgilla canescens* (Grav.). This slender wasp (fig. 64) has a reddish-brown abdomen, with head and thorax black and legs a reddish brown to yellow.

BN-3115

Figure 64.—*Exidechthis canescens*. Enlarged.

The habits of this parasite are somewhat different from those of the preceding species. The adult wasp deposits its eggs inside the body of the flour moth caterpillar and the entire development of the parasitic larva, until just before pupation, takes place within the host. The host caterpillar is not paralyzed and continues feeding until the parasitic larva has become nearly full grown. The developmental period from egg to adult requires between 3 and 4 weeks.

Grain dealers and millers not infrequently find a small, threadlike, white worm (fig. 65), about three-fourths of an inch long, in accumulations of flour or grain dust. This is the larva of a small black fly, *Scenopinus fenestralis* (L.) (fig. 66), known as the windowpane fly from its frequenting the windows of mills and similar establishments. This

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Figure 65.—Larva of a kind of fly that preys upon grain beetles and mites. This white threadlike worm sometimes attains a length of about three-fourths of an inch.

white worm does not injure grain or cereal products but is a predator on other insects found in mills and warehouses. *Scenopinus glabrifrons* (Meig.) is a closely allied species, also known as a windowpane fly.

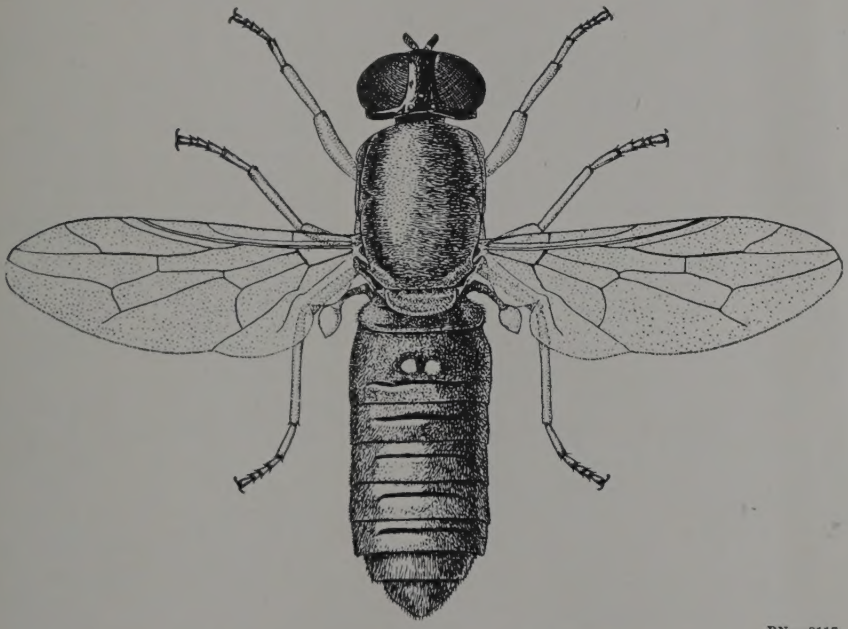

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Figure 66.—Adult of the windowpane fly *(Scenopinus fenestralis.)*. Enlarged.

HOW GRAIN BECOMES INFESTED

Grain may become infested in a number of ways. In many grain-growing regions infestation starts in the field before the crops are harvested. This is, of course, particularly true in the South, where the rice weevil and other insects are abundant in the field at harvest time, and in the soft red winter wheat region of the Eastern States, where the Angoumois grain moth is frequently extremely destructive. In the more northern States that experience severe winters field infestation is a negligible factor.

In addition to field infestation, which may or may not be important, depending on the region or the season, there are several other sources of infestation of stored grain that are of considerable importance.

In all regions it is customary to store grain year after year in the same bins. If these bins are made of wood, cracks and crevices become filled with dust and broken grain and afford places of concealment for many insects. Insects such as the cadelle burrow into the wooden sides or floors to pupate, and later emerge in enormous numbers. Grain bins are not always properly cleaned, hence fresh grain stored in them quickly becomes infested.

Storing bran, shorts, and other milled feeds in or near the granary is another cause of infestation, since

these products are invariably infested. Many bins, too, are located in barns that normally contain products in which insects breed.

Temporary storage of grain in country or crib elevators frequently adds to the danger of infestation. Such storage is difficult to keep free from infestation, and clean grain often becomes contaminated by infested grain arriving at the same place.

Grain may also become infested in railroad boxcars in which it is being transported to terminal elevators. Many grain-infesting insects live in the dust and waste grain that accumulate in cracks in the floors or woodwork and in accumulations behind the linings of the cars.

Storage in warehouses and elevators already containing infested grain also results in contamination through the spread by flight or by crawling of insects from the infested to the clean grain.

Uninfested grain should not be placed for shipment in sacks previously used for grain storage, for, as shown in figure 24, these old sacks often harbor insects unless they have been sterilized by heat or fumigation. Certain extensive and costly infestations have been traced directly to the use of second-hand infested and untreated grain sacks.

Grain stored in the open or in poorly constructed cribs or bins may become infested by insects flying in from outside.

HOW TO PREVENT PRIMARY INFESTATION

With the adoption of the combine harvester, field infestation of small grain has been reduced to a negligible quantity. To prevent infestation after harvest it is recommended that producers: (1) Store only dry grain using weather-tight, rodent-proof bins, preferably of steel; (2) clean out all bins before loading with grain, spray walls and floors of wooden bins, and around door frames of metal bins; (3) clean up and dispose of litter, waste grain, and feed that have accumulated in and around farm buildings; (4) apply protective powder or spray directly to grain as it is binned, or fumigate promptly after binning; and (5) inspect monthly and fumigate if an infestation is discovered.

In the North Central States exposure to winter climates in most years kills out infestations in ear corn stored on the farm, so that loss from insect attack is inconsequential if the corn is to be used for feed during the ensuing season. Following mild winters the Angoumois grain moth may be destructive, and under such conditions it is well to shell corn in May and store in tight bins. In the Southern States field infestation can be reduced by growing varieties with tight shucks that are semi-resistant to field infestation, by disposing of stocks of infested grain in farm storages before the corn reaches the silking stage, by early harvesting, by applying protective powder, by drying and shelling, and by storing in tight bins suitable for fumigation.

Information regarding the prevention of infestation, or the treatment of infested grain is contained in other publications of the Department of Agriculture, copies of which can be obtained from the Office of Information, U.S. Department of Agriculture, Washington, D.C., 20250. Send your request on a postal card.

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